Faculty of Resource Science and Technology

Phenotypic, Taxonomy, Phytochemical and Physiological Characterization of Black Pepper (*Piper nigrum* L.) Cultivars in Malaysia

Chen Yi Shang

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Phenotypic, Taxonomy, Phytochemical and Physiological Characterization of Black Pepper (*Piper nigrum* L.) Cultivars in Malaysia

Chen Yi Shang

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DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulation of Universiti Malaysia Sarawak. Except where due acknowledgnements have been made, the work is that of the author alone. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Signature

Name: Chen Yi Shang

Matic No.: 16010129

Faculty of Resource Science and Technology

Universiti Malaysia Sarawak

Date:

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DEDICATION

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ABSTRACT

To improve the global market competitiveness of Malaysian black pepper, the quality of peppercorn needs to be strengthened. The varietal regulation at farm level is the prerequisite to enhance quality of peppercorn toward strengthening the marketing strategy. This project has comprehensively documented the morphology of ten important black pepper cultivars in Malaysia, namely 'Semongok Aman', 'Kuching', 'Semongok Emas', 'Semongok Perak', 'Semongok 1', 'Nyerigai', 'India', 'Lampung Daun Lebar', 'Sarikei' and 'Yong Petai'. The key diagnosis characteristics are 'Semongok Aman' (Mucronate shaped leaf apex; High percentage of fruit set high, *ca.* 76%), 'Kuching' (High number of inflorescence (spike) per branch per node, *ca.* 58.67; High number of node/feet of stem, *ca.* 4.73), 'Semongok Emas' (Leaf colour of Green Group 137 Series; Fruit colour of Green Group 141 Series), 'Semongok Perak' (Low conversion rate for production of dried black peppercorn, *ca.* 36.12%; Low conversion rate for production of dried white peppercorn, *ca.* 24.21%), 'Semongok 1' (Cordate shaped leaf; Anthocyanin absent at shoot tip), 'Nyerigai' (Erect branching behaviour at mature vine stage), 'India' (Lanceolate shaped leaf; Light seed weight, *ca.* 0.14 g), 'Lampung Daun Lebar' (Oblique shaped leaf base; Blade length-width ratio low, *ca.* 1.52), 'Sarikei' (Small leaf area, *ca.* 36.90 cm^2; Short inflorescence, *ca.* 6.06 cm; Short fruit spike, *ca.* 8.07 cm; Small fruit size, *ca.* 5.78 mm; Small seed size, *ca.* 3.84 mm; Thin pericarp, *ca.* 1.73 mm) and 'Yong Petai' (Long inflorescence length, *ca.* 12.75 cm; Long fruit spike length, *ca*. 17.07 cm; Thin inflorescence, *ca.* 2.90 mm). Phenetic analysis and Principle Component Analysis enlightened that 'Semongok Aman' and 'Semongok 1' have high distinctive value for identification while 'Kuching' and 'Sarikei' have high similarity, thus identification are more complicated. In phytochemical study, analysis showed 'Semongok Aman' and 'Lampung Daun Lebar' has higher piperine

(4.20% and 4.25% respectively) and essential oil content (2.50% and 2.24% respectively). At the same time, this analysis also proved the high pleasant aroma index of peppercorn of 'Nyerigai' (26.11), 'Sarikei' (25.20) and 'Kuching' (18.75). In physiological analysis where the evaluation is based on gas exchange performance and leaf area index, 'Kuching' was proven most productive, followed by 'Nyerigai' and 'India'. Besides, the efficiency of artificial pollination has been improved also via floral biology study. This study suggests pollen collection for all the ten cultivars, ideally between 0400 h and 1400 h while the stigma was proven more receptive at stage where elongation and spreading of stigmata has occurred and the emergence and wide spreading of stigmata has been completed. In general, this study has ensured efficient *in situ* identification of black pepper cultivar base on the identification key produced. Besides, the commercial potential of each cultivar particularly in pharmacological and fragrance industry has also been identified. It was hoped the study outcome could be used as industry guideline to ensure sustainable development of Malaysian black pepper industry in future.

Keywords: Black pepper cultivar; floral biology study; Malaysia; morphological analysis; phytochemical study; physiological analysis; *Piper nigrum* L.

Pencirian Fenotip, Taxonomi, Fitokimia dan Fisiologi bagi Kultivar Lada Hitam (<u>Piper Nigrum</u> L.) di Malaysia

ABSTRAK

Untuk meningkat persaingan pasaran sedunia lada di Malaysia, kualiti lada perlu dipertingkatkan. Pengawalan varieti lada pada peringkat kebun merupakan langkah awal dalam menjamin kualiti lada seterusnya memperkasa strategi pemasaran lada hitam Malaysia. Projek ini telah mendokumentasi mofologi bagi sepuluh jenis kultivar lada utama di Malaysia secara menyeluruh, iaitu merangkumi 'Semongok Aman', 'Kuching', 'Semongok Emas', 'Semongok Perak', 'Semongok 1', 'Nyerigai', 'India', 'Lampung Daun Lebar', 'Sarikei', dan 'Yong Petai'. Kekunci diagnosis bagi ciri-ciri mofologi adalah 'Semongok Aman' (Berbentuk mukronat pada puncak daun dan asas daun; Peratusan kejadian buah yang tinggi, kira-kira 76%), 'Kuching' (Bilangan tangkai bunga yang tinggi, kira-kira 58.67; Bilangan buku ruas dalam sekaki batang yang tinggi, kira-kira 4.73), 'Semongok Emas' (Warna daun jenis Green Group 137 Series); Warna buah jenis Green Group 141 Series), 'Semongok Perak' (Peratus pertukaran lada hitam yang rendah, kira-kira 36.12%; Peratus pertukaran lada putih yang rendah, kira-kira 24.21%), 'Semongok 1' (Daun berbentuk kordat; Antosianin tidak hadir pada hujung pucuk), 'Nyerigai' (Cabang sisi bersifat menegak pada peringkat dewasa pokok), 'India' (Daun berbentuk lanseolat; bijih lada ringan, kira-kira 0.14 g), 'Lampung Daun Lebar' (Asas daun berbentuk serong; Nisbah panjang-lebar daun rendah, kira-kira 1.52), 'Sarikei' (Keluasan daun kecil, kira-kira, 36.90 cm^2; Tangkai bunga pendek, kira-kira 6.06 cm; Tangkai buah pendek, kira-kira 8.07 cm; Buah bersaiz kecil, kira-kira 5.78 mm; Bijih lada bersaiz kecil, kira-kira 3.84 mm; Kulit buah nipis, kira-kira 1.73 mm) dan 'Yong Petai' (Tangkai bunga panjang, kira-kira 12.75 cm; Tangkai buah panjang, kira-kira 17.07 cm;

Tangkai bunga nipis, kira-kira 2.90 mm). Analisis finetik dan Analisis Prinsip Komponen telah membuktikan 'Semongok Aman' dan 'Semongok 1' mempunyai nilai perbezaan yang tinggi untuk pengecaman manakala 'Kuching' dan 'Sarikei' mempunyai persamaan yang tinggi, jadi pengecaman lebih merumitkan. Dalam kajian fitokimia, analisis menunjukkan 'Semongok Aman' dan 'Lampung Daun Lebar' mempunyai kandungan piperine (4.20% dan 4.25% masing-masing) dan kandungan minyak pati (2.50% dan 2.24% masing-masing) yang tinggi. Pada masa yang sama, analisis ini juga membuktikan index aroma wangi yang tinggi pada bijih lada yang dihasilkan oleh 'Nyerigai' (26.11), 'Sarikei' (25.20) dan 'Kuching' (18.75). Dalam analisis fisiologi yang dinilai berdasarkan prestasi pertukaran gas dan index keluasan daun, 'Kuching' telah dibuktikan paling produktif, diikuti oleh 'Nyerigai' dan 'India'. Selain itu, keberkesanan pendebungaan artifisial juga dipertingkatkan melalui kajian biologi bunga. Kajian ini mencadangkan pengumpulan polen bagi semua kultivar sebaiknya dijalankan di antara 0400 jam dan 1400 jam manakala stigma dibuktikan lebih berdaya terima pada peringkat pemanjangan dan perkembangan stigmata telah bermula dan pada peringkat kemunculan dan perkembangan stigmata telah lengkap. Secara umumnya, kajian ini telah memastikan keberkesanan pengecaman kultivar lada hitam secara in situ. Selain itu, potensi komersial bagi setiap kultivar juga dikenalpasti, khususnya dalam industri farmakologikal dan pewangi. Diharapkan hasil kajian ini boleh dijadikan sebagai panduan industri, untuk memastikan kemapanan pembangunan industri lada hitam di Malaysia pada masa depan.

Kata kunci: *Kultivar lada hitam; kajian biologi bunga; analisis mofologi; kajian fitokimia; analisis fisiologi;* Piper nigrum *L.*; *Malaysia.*

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CHAPTER 1

INTRODUCTION

1.1 Background

Piper nigrum L., commonly called black pepper is the world renowned spice from the family of *Piperaceaea*. The peppercorn harvested from the plant not only widely used for food preparation that attributed by unique aroma and pungent properties, but also its pharmacological value (Krishnapura, 2009; Menghani et al., 2010; Meghwal & Goswami, 2012; Butt et al., 2013). The alkaloid compound, piperine, is the compound that contributes to the pungency of black pepper (Krishnapura, 2009; Gorgani et al., 2017) while the aroma is attributed to the volatile oil found in the peppercorn (Nirmala Menon & Padmakumari, 2005). The pharmacological potential that has been scientifically proven include immune modulatory, anti-carcinogenic, stimulatory, hepatoprotective and anti-inflammatory by Darshan and Doreswamy (2004); antimicrobial by Yang et al. (2002); antiulcer activities by Bai and Xu (2000); biotransformative effects and enhance the bioavailability of different drugs by Atal et al. (1985) and Wu (2007); protective effect against radiation by Raman and Gaikar (2002b); Increases pancreatic lipase activity and stimulates pancreatic amylase, trypsin, and chymotrypsin by Platel and Srinivasan (2000) and reduction of blood cholesterol, triglycerides, and glucose by Mueller and Hingst (2013).

The cultivar or cultivated variety of black pepper was believed to have derived from the wild one through domestication (Ravindran, 2000) in the center of origin, the

Malabar Island of India. The plant was introduced to Malaysia as early as 1840 by Hakka Chinese (Mullen, 1960) through Babylonian-Chinese sea trade that linked Malabar Coast and South East Asian ports (Ravindran, 2000). Sarawak and Johore region were the main cultivation area at the beginning stage. However, cultivation only focused in Sarawak in later years with more than 98% of country total production was from this state (Eng & Gumbek, 2007). The distribution in peninsula state and Sabah is limited mainly due to the farmer preference to others crop such as oil palm and rubber. Recent total black pepper planting hectare is around 13,000 hectare (Ibragimov et al., 2015), mainly distributed in rural area of Sarawak. Approximately 18,000 to 20,000 pepper farm families, with 68,000 to 70,000 people involved in pepper cultivation (Wong, 2016).

The most common black pepper cultivar is cv. 'Kuching', which is widely planted throughout Sarawak (Sim, 1991). However, Paulus (2007) reported three important cultivars in Malaysia, namely cv. 'Semongok Perak', cv. 'Semongok Aman', and cv. 'Kuching'. Through the International Pepper Community (IPC) exchange program, cv. 'Lampung Daun Lebar' and cv. 'Lampung Daun Kecil' were introduced to Malaysian farmers (Sim, 2007). In recent year, a manual entitled 'Pepper production technology in Malaysia' released by the Malaysian Pepper Board, reported the existence of seven cultivated varieties as common cultivars in Malaysia, including cv. 'Semongok Aman', cv. 'Semongok Emas', cv. 'Kuching', cv. 'Semongok Perak', cv. 'Uthirancotta', cv. 'Nyerigai', and cv. 'PN129'(Paulus, 2011a). However, there is no varietal restriction or regulation in black pepper planting in the past until nowadays. Thus, the diversity of the black pepper cultivar in Malaysia black pepper farm is unrevealed.